Developing Regulatory Methods for Integrating Life Cycle Assessment into Alternatives Analysis for Identifying Safer Substitutes for Hazardous Products

Life Cycle Assessment Symposium
Department of Toxic Substances Control
Oakland, California

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Peter Sinsheimer, Ph.D., MPH
UCLA Law and Environmental Health
Sustainable Technology Policy Program

UCLA Sustainable Technology & Policy Program

- Mission:
  - Assist in the development and use of safer chemicals and alternative manufacturing processes in the marketplace.
- Key Priority Areas:
  - Identification, tracking and evaluation of hazardous chemicals and technologies.
  - Development and evaluation of tools for business and policymakers seeking to reduce toxics use.
  - Identification and assessment of existing and emerging alternative chemicals and technologies.
  - Identification and analysis of legal, economic and social barriers to and drivers of the diffusion of alternatives.

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STPP Key Components

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Presentation Outline

- AB1879 and Life Cycle Assessment requirements
- LCA and Alternatives Assessment
- Alternatives Analysis Framework: Alt Assessment → Alt Evaluation
- Understanding the AA Framework: Case Study of Dry Cleaning
- Key Components of Alternatives Evaluation:
  - Guiding Principles
  - Multi Criteria Decision Analysis
- Conclusion

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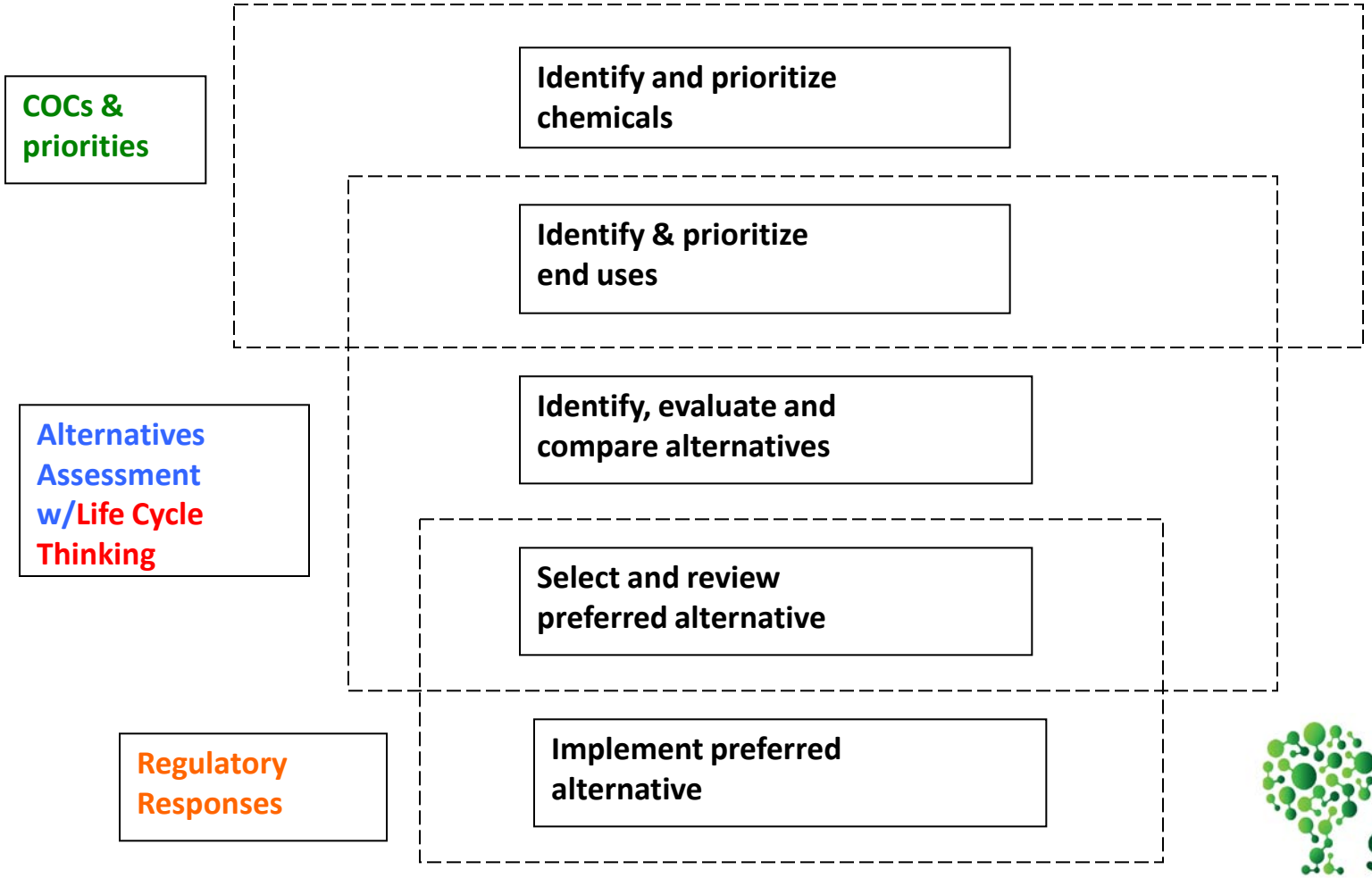
AB1879 Structure



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AB1879 Statutory Requirements for LCA

25253. (a) (2) "The regulations adopted pursuant to this section shall establish a process that includes an evaluation of the availability of potential alternatives and potential hazards posed by those alternatives, as well as an evaluation of critical exposure pathways. This process shall include life cycle assessment tools that take into consideration, but shall not be limited to, all of the following:

(A) Product function or performance.
(B) Useful life.
(C) Materials and resource consumption.
(D) Water conservation.
(E) Water quality impacts.
(F) Air emissions.
(G) Production, in-use, and transportation energy inputs.
(H) Energy efficiency.
(I) Greenhouse gas emissions.
(J) Waste and end-of-life disposal.
(K) Public health impacts, including potential impacts to sensitive subpopulations, including infants and children.
(L) Environmental impacts.
(M) Economic impacts."

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General LCA Criteria Indentified in AB1879

Criteria	AB1879: Section 25253 (a) (2)
Technical Performance	• Product function or performance (A)
Cost	• Economic impacts (M) • Useful life (B)
Environmental Impact	• Materials and resource consumption (C) • Water conservation (D) • Water quality impacts (E) • Air emissions (F) • Production, in-use, and transportation energy inputs (G) • Energy efficiency (H) • Greenhouse gas emissions (I) • Waste and end-of-life disposal (J) • Environmental impacts (L)
Human Health	• Potential hazards posed by those alternatives (Sec. 2) • Critical exposure pathways (Sec 2) • Public health impacts, including potential impacts to sensitive subpopulations, including infants and children (K)

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AB1879 LCA Requirements

Criteria	Target Product	Alternative 1	Alternative 2
Human Health	Extraction	Extraction	Extraction
	Production	Production	Production
	Product	Product	Product
	End-of-Life	End-of-Life	End-of-Life
Environmental Impact	Extraction	Extraction	Extraction
	Production	Production	Production
	Product	Product	Product
	End-of-Life	End-of-Life	End-of-Life
Cost	Extraction	Extraction	Extraction
	Production	Production	Production
	Product	Product	Product
	End-of-Life	End-of-Life	End-of-Life
Performance	Product	Product	Product

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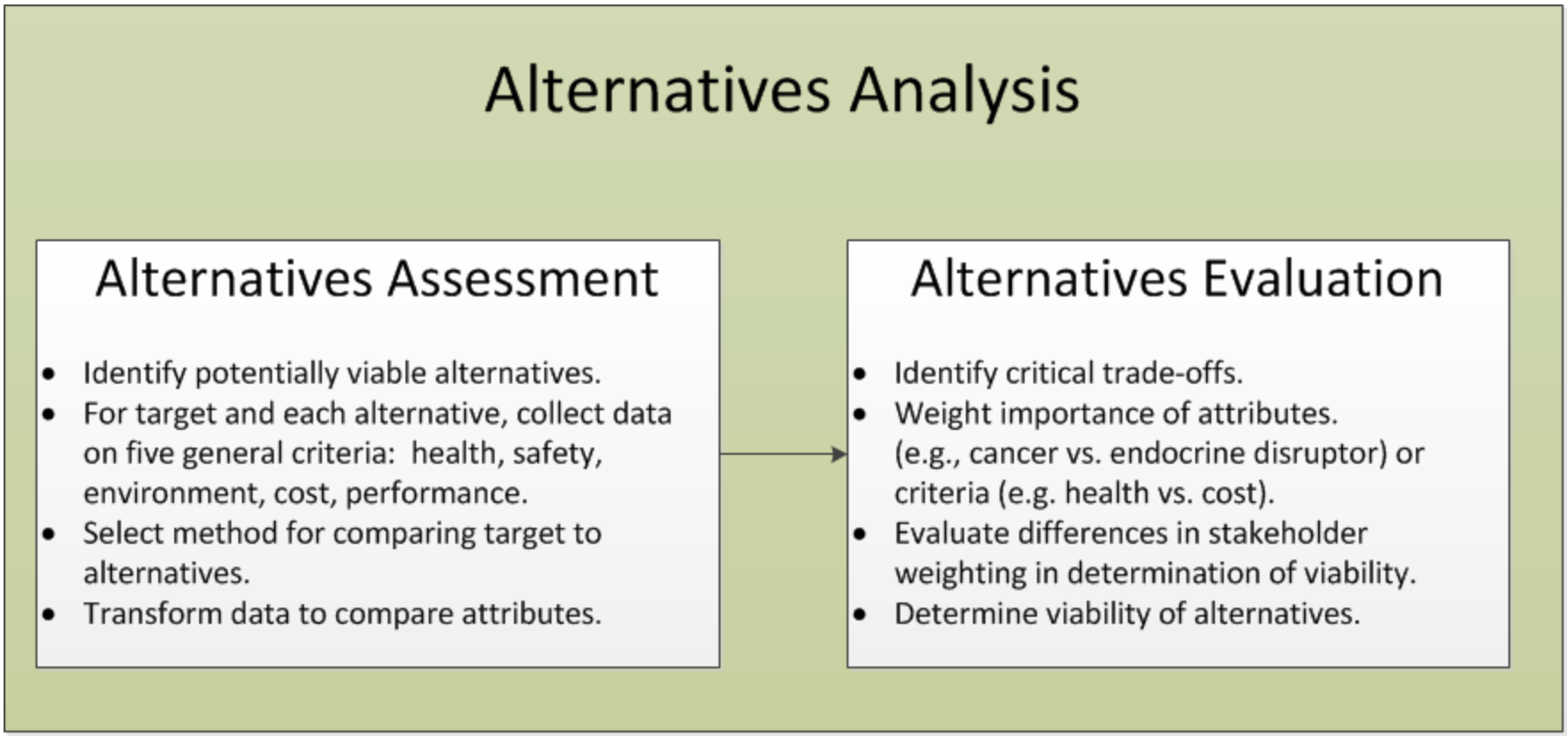
Alternatives Analysis Framework*



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* Sinsheimer, P; Malloy, T. Integrating Safer Alternatives into Chemical Policy: Developing a Regulatory Framework for AB 1879, STPP White Paper, December 2009.

Key Factors in Measuring and Evaluating Alternatives Analysis Measures

	Private LCA/AA	Gov't LCA/AA
Assessment		
• Which attributes to measure	Firm, Cons	Statute, Agency
• How to measure attributes	Firm, Cons	Statute, Agency
• Who measures attributes	Firm, Cons	Agency, 3rd party
• How to deal with uncertain data	Firm, Cons	Agency, 3rd party
Evaluation		
• How to compare attributes and categories	Firm, Cons	Agency, 3rd party
• How to weight attributes and categories	Firm, Cons	Agency, 3rd party
• How to determine overall viability	Firm, Cons	Agency, 3rd party
Decision making process		
• Who determines action based on viability	Firm	Agency

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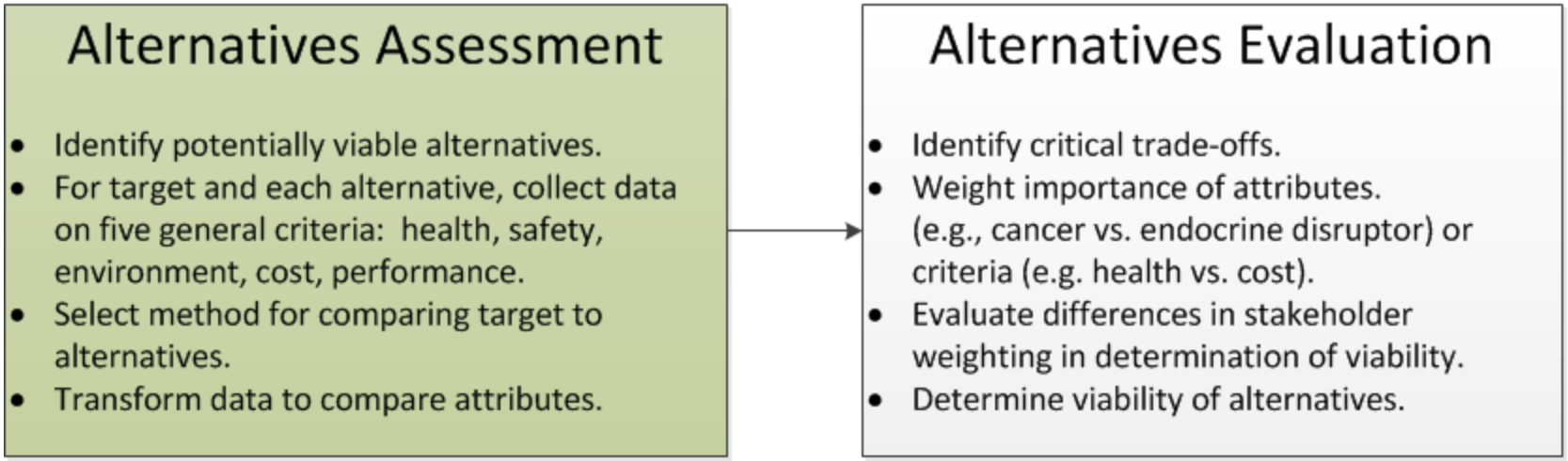
Alternatives Assessment



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Alternatives Assessment Data Collection

Human Health	Environmental	Performance	Cost
Measures • Carcinogen • Mutagen • Rep/Dev/Immul toxicity • Endocrine disruptor • Cardiovascular • Allergen/Irritant • Occ exposure limit • Sub-population	Measures • Eco toxicity • Biodegradability • Bioaccumulation • Water: quality & use • Air: OD, GG, HAP, VOC • Energy use • Extraction hazards • End-of-life disposal	Measures • Performance of product or process • Training • Maintenance • Durability • R&D assessment • Potential enhancements • Social utility	Measures • Market price • Raw material cost • Life cycle cost • Operating cost • Capital equipment cost • Relative nominal cost • Economies of scale • Price sensitivity (material/labor, etc)
Data Methods • In vivo • In vitro • Structure activity relationships	Data Methods • Laboratory tests • Field tests	Data Methods • Laboratory tests • Field tests • Questionnaires • Interviews • Industry standard	Data Methods • Field research • Questionnaires • Interviews
Expertise • Toxicology • Epidemiology • Chemistry • Molecular Biology	Expertise • Biology • Toxicology • Engineering • Envi Science	Expertise • Engineering • Chemistry • Manufacture • End user • Trade association	Expertise • Economist • Engineering • Manufacture • End user • Trade associations

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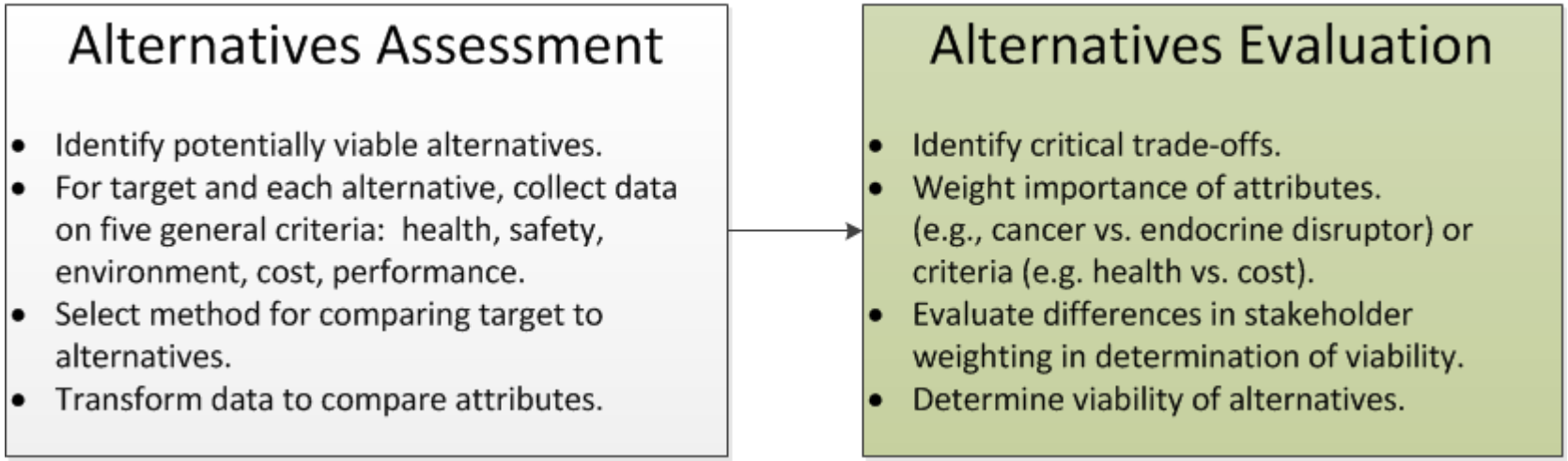
Alt Assessment Matrix: PCE Dry Cleaning

Assessment Criteria		PCE Reference	Hydro Carbon	Siloxane	n Propyl Bromide	CO2	Wet Cleaning
Human Health	Carcinogenicity	2A	+	?/=	?/=	+	+
	Mutagenicity	No	=	=	=	=	=
	Repro/D.Tox	No/?	=	=	-	=	=
	Dermal/Oral/Resp.	Irritant	?	+	-	=	=
	Exposure Limits	100 ppm	+	-	-	?	+
Safety	Flammability/Comb	Non-F	-	-	?	-	=
	Reactivity	Non-R	=	=	=	=	=
	Corrosivity	Non-C	=	=	=	=	=
Enviro	Water	60 days	+	+	+	+	+
	Soil	120 days	-	+	+	+	+
	Sediment	540 days	+	+	+	+	+
	Air	98 days	-	+	+	-	+
	VOC emissions	No	-	+	=	=	=
	Energy		-	-	?	+	+
	BCF	83	-	+	-	+	+
Technical	Time	45 min	-	-	=	=	=
	Load Capacity	60 lbs	-	+	=	=	=
	# of Soils		-	-	=	=	=
	Clothing Types		+	=	=	+	=
	Spotting Requirements		-	-	=	=/-	=
	Training		=	=	=	=	-
Financial	Equipment		-	-	+	-	+
	Solvent		+	?	=	?	+
	Labor		-	?	=	?	=
	Operating		=	?	=	?	=
	Regulatory		+	=	?	+	+

Comparison Key: Alternative to Target : -- + Better = Similar – Worse ? Unknown

Alternatives Evaluation



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Identifying Key Trade-Offs

PCE Dry Cleaning vs. Alternatives

Criteria	PCE	Petrolum	Siloxane	nPB	CO2	PWC
Human Health	CA		? CA ↑ Occup. Risk	↑ Repro ↑ Occup. Risk		
Safety	No Fire	↑ Fire	↑ Fire	↑ Fire		
Environment	↑ Persist.	↑ VOC				
Performance		↓ Perf				↑ Training
Cost		↑ Cost	↑ Cost		↑ Cost	

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Alternatives Evaluation Methods

-- Weighting Criteria for Determining Viability --

- Guiding Principles
  - Qualitative approach
- Multi-Criteria Decision Analysis
  - Quantitative approach
- Hybrid

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Guiding Principles Method

-- Example --

SNAP: Significant New Alternatives Program

(Verifies safety of substitutes for ozone-depleting compounds)

<u>Guiding Principles</u>

- Substitutes evaluated within a comparative risk framework.
- Substitutes not require to be risk-free to be found acceptable.
- Restrict only those substitutes that are *significantly* worse to human health and the environment.
- Evaluate risks by use.
- Provide regulated community with information as soon as possible.
- Do not endorse products manufactured by specific companies.

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Guiding Principles Method

-- Example --

Superfund Guiding Principles for Selecting Remediation Options

<u>Guiding Principles</u>

- Overall protection of human health and the environment.
- Compliance.
- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, or volume.
- Short-term effectiveness.
- Implementability.
- Cost.
- State acceptance.
- Community acceptance.

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Draft AB1879 Guiding Principles (§ 69301.1.)

"In fulfilling their respective requirements and responsibilities under this chapter, the Department, manufacturers, and responsible entities, and persons acting on behalf of one or more of the aforementioned, shall base their analyses and determinations on the best scientific principles and practices, and shall be guided by the following principles:

(a) Green chemistry principles and life cycle thinking should be considered throughout implementation of the regulations in this chapter.

(b) Adverse impacts on public health and the environment that may result from the production, use or end-of-life management of consumer products and consumer product chemical ingredients should be significantly reduced or eliminated, to the extent technologically and economically feasible. "

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Draft AB1879 Guiding Principles (cont)

"(c) Adverse public health and environmental impacts of chemicals used in commerce, as well as the overall costs of those impacts on the people of California, should be significantly reduced, by encouraging the redesign of consumer products and manufacturing processes and approaches, while maintaining or enhancing product function and performance.

(d) Chemical and consumer product prioritization processes should seek to identify and give priority to those chemicals, and the consumer products that contain them, that pose the greatest public health and environmental threats, are most prevalently distributed in commerce and used by consumers, and for which there is the greatest potential for consumers or environmental receptors to be exposed to the chemical in quantities that can result in public health or environmental harm."

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Multi-Criteria Decision Analysis (MCDA)

- *Decision theory* discipline aimed at supporting decision makers facing numerous and conflicting evaluations. MCDA highlights conflicts and deriving a way to come to an optimum decision in a transparent process.

- Allows for broad range of stakeholder input.

- Application of MCDA in environmental decision-making:
  - Hazardous waste remediation
  - Watershed management
  - Fisheries
  - Wildlife management
  - Land use planning

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Range of MCDA Methods

- *Noncompensatory Methods*: good score on one attribute can't compensate for bad score on another
  - Examples:
    - Conjunctive: alternative acceptable if it meets minimum cutoff for all attributes.
    - Pros & Cons: alternative with strongest pros and weakest cons selected.
    - Maximin: choose alternative where weakest score is highest.

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Range of MCDA Methods

- *Compensatory/Partially Compensatory Methods*: good score on one attribute can compensate for bad score on another
  - Examples:
    - Multi-Attribute Utility Theory: Transforms diverse criteria (cost, risk, etc) into common dimensionless scale. Assigns weights to each criteria to derive an overall score for each alternative.
    - Outranking: One alternative outranks another if it outperforms the other on enough criteria of sufficient importance and is not significantly outperformed on any one criteria.

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MCDA Thinking in Regulatory Decision Making

-- Example: CARB ATCM for PCE Dry Cleaning --

ARB Staff Recommendation

Policy Options	Content	Analysis
Staff Recommendation	No PCE phase out	Engineering controls sufficient to create acceptable risk.
Option 1	PCE phase out	Most of market would go to petroleum and create unacceptable increase in VOC.
Option 2	PCE and petroleum phase out	Most of market would go to siloxane and create unacceptable increase in cost.

ARB Board Decision

Policy Options	Content	Analysis
Staff Recommendation	No PCE phase out	Engineering controls sufficient to create acceptable risk.
Option 1	PCE phase out	Most of market would go to petroleum and create unacceptable increase in VOC.
Option 2	PCE and petroleum phase out	Most of market would go to siloxane and create unacceptable increase in cost.

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MCDA Method Used in CARB PCE Dry Clean Ruling

- Outranking and/or Conjunctive
  - Staff weighting:
    - Option 1 (PCE phase out) rejected because another attribute (VOC emissions) weighted by staff as significantly worse.
    - Option 2 (PCE and VOC phase out) rejected because another attribute (cost) weighted by the staff as significantly worse.
  - Board weighting:
    - Option 1 (PCE phase out) accepted because PCE phase out outperforms staff recommendation (engineering controls) and no another attribute (including VOC emissions) weighted by the Board as significantly worse.
    - Option 2 (PCE and VOC phase out) rejected because another attribute (cost) weighted by the Board as significantly worse.

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Public Health Trust Grant

- Develop regulatory alternatives analysis methodologies for the CA GCI.
- Conducting two real-life case studies of hazardous chemical uses for which potential alternatives exist.
- Bring together experts in regulatory policy, toxicology, alternatives assessment, and decision analysis to develop and evaluate an alternatives analysis methodology that includes:
  - stakeholder preferences to support weighting of decision criteria
  - development of formal multi-criteria decision analysis
  - generation of software alternatives analyses in a regulatory setting.

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Conclusion

- Regulatory integration of LCA into Alternatives Analysis is feasible and has been demonstrated.
- Guiding principles provide qualitative direction in making choice of safer substitutes.
- MCDA methods need to be developed identify critical trade-offs and develop optimal solutions.
- Broad range of stakeholders should be engaged in the development of MCDA methods.
- Development of MCDA likely to take time.
- Over time, guiding principles and MCDA will lead to effective and efficient AB1879 implementation.
- Efficient and effective implementation will drive innovation and diffusion of safer substitutes.

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Contact Information:

Peter Sinsheimer, Ph.D., MPH
UCLA Sustainable Technology & Policy Program
Tel: 310.794-1408
Email: petersinsheimer@ucla.edu

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